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EDITOR

C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS

OTTO KLOTZ
Chief Astronomer and Director
Dominion Astronomical Observatory, Ottawa

SIR FREDERIC STUPART
Director of the Meteorological
Service of Canada, Toronto

J. S. PLASKETT
Director of the Dominion Astrophysical Observatory
Victoria, B.C.

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Editorial communications should be addressed to C. A. Chant, University of Toronto, Toronto, Ont.

Business correspondence, remittances, etc., should be addressed to H. W Barker, Treasurer of the Society, 198 College Street, Toronto.

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THE DOMINION ASTRONOMICAL OBSERVATORY AT OTTAWA

BY OTTO KLOTZ

THE Observatory at Ottawa to-day is an evolution of the astronomic work inaugurated in 1885 in connection with the Railway Belt in British Columbia.

British Columbia entered Confederation, became part of the Dominion of Canada, on July 20, 1871.

One of the conditions upon which British Columbia entered the Dominion was the speedy construction of a trans-continental railway, and in this connection, by the Imperial Order in Council of the 16th May, 1871, British Columbia conveyed in trust of her Crown Lands to the Dominion ". . . . not to exceed twenty miles on each side of the said line" (railway). These twenty miles on each side of the railway are known as the Railway Belt, and became Dominion Lands, to be administered by the Department of the Interior, and furthermore, to be correlated with the Dominion Lands survey system of the Northwest, a system based on geographic co-ordinates.

The mountainous character of British Columbia precluded projecting and running standard base-lines and meridians, as had

been done over the wide expanse of prairie from Winnipeg to Calgary and Edmonton. However, another method was available, and that was to establish a number of astronomic stations accurately determined in latitude and longitude along the railway line, and furthermore to make a very accurate azimuth survey of the railway connecting the survey with the astronomic stations. With these data it was thus possible to compute with precision the position on the earth, that is, in latitude and longitude, of every point of the railway, and hence the position it would occupy were the rectangular net of Dominion Lands Survey spread over the Railway Belt, becomes known. The distance involved in this survey was 512 miles, extending from Port Moody, the original Pacific terminus, to the summit of the Rocky Mountains.

In 1885 there was no Vancouver; it subsequently became the terminus. Accordingly in the spring of 1885 (the last spike of the railway was driven at Craigellachie on November 7, 1885), the Surveyor General, E. Deville, issued instructions to two astronomers, T. Drummond and Otto Klotz, to make the astronomic observations, and to W. Ogilvie to make the azimuth survey. It may be noted that the official use of the word astronomer by the Department was for the first time made in the above case.

The beginning was made from the Pacific end of the line, and the writer had charge of the astronomic work. The nearest well-determined point was Seattle, the astronomic position being determined by the U. S. Coast and Geodetic Survey, its longitude being based on Greenwich. Hence Seattle became the initial point for our longitudes, and from it were established Victoria and Kamloops, the latter becoming in turn the basal longitude station, to which were referred Port Moody, Revelstoke, Field and other stations as far east as Winnipeg.

The astronomic equipment consisted of two Troughton and Simms portable transits, Fo. 1, and Fo. 2, each of 2½-inch aperture and 28 inches focal length, previously used on the 49th parallel Boundary Survey of 1872-1874; two sidereal box chronometers by Dent and Frodsham, respectively; two pocket chronometers; one zenith telescope for latitude work, and two standard registers

of the Western Union Telegraph Company, on the tapes of which the clock signals, sent by hand, were recorded. In 1885, besides occupying Seattle, the positions of Victoria, Port Moody and Kamloops were determined, and the azimuth survey carried from Port Moody to Farwell, now Revelstoke. In the following year Revelstoke, Field, Calgary and Winnipeg were occupied.

At Calgary a connection was made with the 5th Initial Meridian, and at Winnipeg subsequently with the Principal Meridian and with longitudes from the east for a comparison with the longitude brought across the continent through the United States and eastward again via Seattle and British Columbia.

The success of these two years of astronomic work in connection with the accurate determination of geographic positions for the Department of the Interior gave astronomic work a permanent footing in the Technical Branch under the Surveyor General, E. Deville, and this led to an extension of its application to a wider field, not only within the vast area of Dominion Lands in the Northwest, but also in other parts of Canada for cartographical and other purposes.

It was essential that the longitude of Winnipeg be well established by connection with the east (Harvard), as it was to serve as a base station. The adopted longitude of Winnipeg rested upon a rather unsatisfactory determination of West Lynne from Dearborn Observatory, Chicago. By linear measure from West Lynne along the 49th parallel, the international boundary line, the longitude of the Principal Meridian was established, and by triangulation from the latter to Winnipeg the longitude of Winnipeg was found.

On February 10, 1887, the Surveyor General, E. Deville, submits to the Deputy Minister a memorandum suggesting the establishment of an observatory at Ottawa in connection with the longitude work in the west. This was approved by the then Minister, the Hon. Thos. White, but nothing was done.

In March, 1887, W. F. King and the writer officially visited Boston, Cambridge, New York and Washington, with the object of inspecting, subsequently to purchase, a transit for the proposed

permanent observatory at Ottawa; a portable transit for field work, as W. Ogilvie had taken one of our portable transits used in 1885 and 1886 on his exploratory trip down the Yukon; a sidereal clock; two box chronometers and a standard barometer. When C. Carpmael, director of the Meteorological and Magnetic Observatory, heard of the above errand and the proposed erection of a permanent astronomic observatory at Ottawa, there was a tempest in a teapot for a short time. In May, 1887, a temporary observatory was built in the garden of W. F. King, in which the Russell alt-azimuth to be used by King the coming season was tested. In this year W. F. King, Chief Inspector of Surveys, became associated with the writer in astronomic work in the west, when Wapella, Port Arthur and Kalmar were occupied, besides Winnipeg, by King as reference stations in longitude.

Proceeding to the west together, King and the writer visited en route the observatories at Ann Arbor, Mich.; at Madison, Wis., and at Northfield, Minn. At Winnipeg we connected by triangulation the 1872 longitude point, flag-pole at Fort Garry, with the temporary observatory of 1886, north of the C.P.R. and on the east side of Main Street.

In July, 1887, a new transit was ordered from Cooke and Sons, England.

In October, 1887, Deville wrote to King at Winnipeg, "that the observatory building (Ottawa) is in a worse muddle than ever," and suggested connecting Winnipeg with Cambridge (Harvard), with Ottawa intermediate. King at latter, Klotz at other two stations.

October 18, 1887, King wrote from Kamloops to Deville about the astronomic work and expressed desirability of a permanent observatory at Ottawa.

October 25, 1887, the Minister (Hon. T. White) informed Klotz, re erection of observatory at Ottawa, "My colleagues opposed it, so I dropped it for the present in order to gain my point eventually."

October 30, 1887, Klotz to Surveyor General, again urging

the erection of an observatory at Ottawa—"an efficient transit room to start with."

November 9, 1887, Klotz to Surveyor General, sending photograph of Brashear's 8½-inch reflector, cost $300, which the former was prepared to buy himself for observation of occultations in conjunction with Ogilvie's observations on the Yukon, near the 141st meridian. The Department bought the reflector.

It may be noted that at this time both the Surveyor General, E. Deville, and the Chief Inspector of Surveys, W. F. King, were permanent officers of the Department, were in the Inside Service, while the writer was on day pay and not resident in Ottawa, although Ottawa was his official headquarters.

On February 22, 1888, the writer submitted a long letter to the Surveyor General on the subject of the erection at Ottawa of an astronomic observatory. The letter was signed jointly by W. F. King and the writer. It was approved by the Surveyor General and forwarded to the Deputy, who submitted it for favorable consideration to the Minister.

On February 27, 1888, five days after the above letter, the Surveyor General submitted a long memorandum on the same subject—advocating a permanent observatory at Ottawa—to the Deputy; the latter asked the former to obtain the concurrence of King and Klotz, which was gladly given, Klotz, however, writing that he considered the estimate of cost too law. The Deputy (A. M. Burgess) was throughout favorable to the proposition.

Due to the untimely death of the Minister, the Hon. Thos. White, April 21, 1888, the Deputy wrote to the Surveyor General that "our late Minister had not taken any action upon this before his death," and asked Deville to keep the subject in mind when the new Minister of the Interior would be appointed.

Early in 1888, the new Cooke & Sons transit, 3-inch aperture, 34-inch focal length, was received, and was mounted by the writer at the new observatory (Princess Street) at Winnipeg, May 31, 1888; also a sidereal clock with electric attachments, which was set up in the basement of the Clarendon Hotel, Winnipeg. The Brashear equatorial also was set up at Winnipeg. During this

year Edmonton and Onion Lake (110° meridian) were occupied and connected in longitude with Winnipeg.

About this time the Alaska boundary question occupied the attention of the Department of the Interior more and more, and the astronomic work was temporarily suspended, but the observatory scheme was kept alive. A good deal of correspondence took place between the Department of the Interior and those of the Public Works and Railways and Canals about a site for the temporary observatory, either along the Canal Basin or on a Government lot on Cliff Street.

On June 30, 1890, by order-in-council a new office was created—Chief Astornomer—and W. F. King, Chief Inspector of Surveys, was appointed thereto at a salary of $1,800 per annum.

It is important to note that during these years, and for some years subsequently, there was no thought of an observatory with dome nor of engaging in astrophysical work; this was a later evolution, on the advent of the Hon. Clifford Sifton as Minister of the Interior, who wanted a creditable astronomic outfit and building, representing the National Observatory of Canada.

The Surveyor General, the Chief Astronomer and the writer were at the time more concerned about a permanent observatory at Ottawa, as the initial place of reference for longitude work throughout Canada, with the installation of transits, and later a meridian circle for fundamental work. It was hoped ultimately to expand the astronomic work of latitude and longitude that had been carried on for some years to include a trigonometrical or geodetic survey, towards which the writer had labored and written for many years.

In 1890, W. Ogilvie made an exploratory survey from Lake Timiskaming to and along part of James Bay. The meridian from the head of the lake forms the boundary line between Ontario and Quebec. To determine its longitude, it was by survey connected with Mattawa, and the difference of longitude between Mattawa and Ottawa was determined by the Surveyor General and the Chief Astronomer, although the accurate longitude of Ottawa had not been established.

In 1892 the astronomic work was in so far resumed that the Department took part (by the writer) in a fresh trans-Atlantic longitude determination connecting Greenwich with Montreal via Waterville in Ireland, and Canso, N.S., the termini of the Commercial Cable.

The Chief Astronomer was appointed in 1892 H. M. Boundary Commissioner, so that his and the writer's time was occupied with the Alaskan Boundary survey during the following three years.

In 1896 the astronomic work was resumed by King and Klotz. Port Stanley on Lake Erie for international boundary purposes was established, and Winnipeg connected with Ottawa, while Ottawa was connected with Montreal by Professor McLeod and the Chief Astronomer.

The year 1896 saw a change of government, and the Hon. Clifford Cifton became Minister of the Interior, and the writer became a permanent official and entered the Inside Service with the official title of Astronomer.

On the 23rd April, 1897, the Chief Astronomer asked the writer to draw up specifications for a new transit to be ordered from Cooke & Sons, and shortly afterwards the instrument was ordered. It was received early in 1898, as well as a break-circuit chronometer, No. 48419, from E. Dent & Co., London.

On 15th April, 1898, the writer recommended the purchase of another and better chronograph from Warner and Swasey.

On June 7, 1898, the Chief Astronomer submitted a memorandum to the Minister, the Hon. Clifford Sifton, on the subject of an adequate observatory—with 10-inch refractor, a star spectroscope, a sidereal and a mean time clock, a chronograph and pendulum apparatus at a total cost of $7,800. The chronograph was authorized to be purchased from Warner and Swasey for $400, and was obtained.

On June 23, 1898, the Chief Astronomer wrote the Deputy, J. A. Smart, that he did not expect immediate action by the Minister to his memorandum of the 7th inst., save on the chrono-

graph, but simply directed the attention of the Minister and Government to the subject as worthy of consideration.

In June, 1898, the writer, en route to Russia, took the chronometer, 4841?, to Dent, London, for electric alterations.

On November 4, 1898, the writer prepared a list of the 85 observatories in the United States and of 252 observatories in other countries, giving their equipment, with special reference to the dimensions of their equatorials. This list was included in the memorandum November 7, 1898, to the Minister by the Chief Astronomer, in which details and reasons were given for a proposed national observatory and its equipment. The cost of the building, $7,000, had also been furnished by the writer. The total cost submitted—without cost of site—was $16,075. The equatorial recommended was of 10-inch aperture.

On November 10, 1898, the Minister requested the Chief Astronomer to let him know what other observatories there were in Canada and the nature of their work.

On November 15, 1898, the Chief Astronomer replied that there were only two, one at Toronto and the other at McGill, and that their work did not interfere with that contemplated at Ottawa.

In a letter, 26th May, 1899, the Public Works Department informed the Chief Astronomer that the sum of $16,000 for the instruments and building had been placed in the Supplementary Estimates for next year.

On the 19th August, 1899, the Chief Astronomer wrote to the Minister of the Interior that steps should be taken to begin the construction of the observatory, pointing out, however, that the architect had deferred the preparation of the plans until the site was chosen, as "the site of the building must determine its architectural character." The sites suggested by the Chief Astronomer were: "the knoll on Parliament Hill, just behind the Western Block; another is the site of the summer-house west of the Library; and the third is in Major's Hill Park, on the Mackenzie Avenue side and about half-way between Rideau and St. Patrick Streets." The preference was for the "knoll."

On August 23, 1899, the writer interviewed the Minister

(Mr. Sifton) on several official matters, the most important of which was the proposed site on Parliament Hill for the observatory. An emphatic protest was entered against the contemplated site as unsuitable and wholly inadequate for the national observatory of Canada. Cogent and unanswerable reasons were advanced against the site. The Minister gave a sympathetic hearing.

On January 10, 1900, the Chief Astronomer submitted to the Deputy a memorandum stating that the plans were in preparation, but were for a much more expensive building than contemplated, and hence a larger and more expensive instrument was required to lessen the disproportion in cost. About the site—Parliament Hill—the Chief Astronomer said "it would be difficult to get another so suitable astronomically and so convenient for office purposes" (as it is essential that the Chief Astronomer's office should be in the building). A decision by the Minister was requested.

On January 13, 1900, an officer of the Chief Architect's office brought an architecturally elaborate and colored plan of the proposed observatory to King (and me) for him to make suggestions, but only with reference to the interior, as the Chief Architect desired no change in the exterior. This plan was essentially for an architectural monument. By this plan the equatorial would be about 48 ft. above the ground floor, and nearly 60 ft. from the basement for a 10 or 12-inch glass.

On January 17, 1900, the writer called on the Deputy re observatory. The Deputy had the plan, and said, "It looks pretty, but I told the Minister if a $50,000 or $60,000 building was to be put up, provision must be made in the estimates for instruments fitting such a building; if the Government wants to spend $50,000 or $60,000 on a building, I don't care." "For my part," I added, "if that sum of money is to be spent, I prefer to have a suitable site bought and have a less ornamental, yet fully as—yes, more so—useful, building erected." I explained the scope our work must necessarily eventually take, and that the proposed 100-foot "knoll" was wholly unsuitable. The Deputy said, "I guess you are right." "I know I am right," was my reply.

On the 24th January, 1900, the Chief Astronomer asked the Deputy to put $8,000 in the estimates for a 12-inch equatorial. On February 19, 1900, the Chief Architect sent to the Chief Astronomer a sketch of the proposed observatory.

In the latter part of February the Chief Astronomer visited Cleveland and Allegheny re instruments.

On March 5, 1900, Warner & Swasey, of Cleveland, submitted an estimate of 12-inch telescope and many accessories for $9,085. On April 18, 1900, an astronomic clock for $550 was ordered from the E. Howard Watch & Clock Co., Boston, and subsequently placed (for uniform temperature) in the basement of the Supreme Court building.

What equipment we had in our old wooden observatory on Cliff Street, is found from the following list, made on the removal of the instruments on the night of the big fire in Hull and Ottawa, April 26, 1900: 2 switchboards, 1 watch chronometer; 1 old chronometer, No. 81; 1 new Dent chronometer; striding level in case; old and new Cooke transits; galvanometer; relays; chronograph; Siemens switchboard, and instrument lamps.

During this year, 1900, astronomic work was resumed and Rose Point, Owen Sound, Chalk River, Vancouver, Rayside and Wilno were occupied, and connected in longitude with Ottawa. On Nov. 6, 1900, a complete magnetic field outfit, for the contemplated magnetic survey of Canada under the direction of the Chief Astronomer, was ordered for 1,400 marks from Tesdorpf, Stuttgart.

On February 14, 1901, the Deputy informed the Chief Astronomer, with reference to the observatory, that the Minister was inclined to think that "it is very doubtful if anything will be done this year." However, later an item of $15,000 appeared in the estimates.

March 11, 1901, Chief Astronomer to J. A. Brashear, saying, "Sorry; observatory scheme fallen through for the present."

May 22, 1901, J. C. Grant to Minister, offering 7 acres along the Rideau—Salisbury Avenue—at $3,000 an acre for observatory site. It may be stated that the Chief Astronomer and the

writer had examined various vacant lands in Ottawa for a site, and the two that were considered suitable were: the preceding overlooking the Rideau, and the other beyond the T. C. Keefer property at Rockcliffe on the high land and overlooking the Ottawa; but the Minister was disinclined to purchase land.

On May 28, 1901, the Chief Astronomer asked the writer to make a rough plan of the Observatory, which he did. (It is preserved in the library of the Observatory.)

June 3, 1901, Chief Astronomer to Deputy, asked authority to order telescope and to visit Cleveland and Allegheny to make contract. The Minister approved and our 15-inch telescope was ordered.

On June 18, 1901, the writer called on the Minister, when the latter said he had tentatively chosen a site at the Experimental Farm (being the little rising ground where now the large supply tank stands). He asked the writer to look over the Farm, as the Observatory must be on Government ground, as there was no appropriation for the purchase of land.

On June 19, 1901, the writer examined the Farm and determined upon the best site.

On June 20, 1901, the Chief Astronomer and the writer visited the Farm together. The Chief Astronomer agreed and concurred in the choice made by the writer, and immediately 'phoned the decision to the Minister—Mr. Sifton—who agreed thereto, also the Minister of Agriculture, under whose jurisdiction the Farm is. And so the final site of the Observatory was settled, and there the Observatory stands to-day.

On June 22, 1901, the writer made a survey of the Observatory site for expropriation puproses.

On June 25, 1901, the writer showed the Minister the rough ground plan drawn for the Observatory, which he asked him to show to the architect; the Chief Astronomer had similarly drawn a rough plan for the architect. The former plan had a straight front, while the latter was in the form of an L. The architect combined the two with an angle of 150° between the two wings, to which we agreed, and this form the Observatory has.

To Warner & Swasey, of Cleveland, was awarded the contract for the mechanical parts of the equatorial, and also for the dome, while J. A. Brashear, of Allegheny, received the contract for the optical parts of the 15-inch equatorial; spectroscopic grating, etc.

From Clemens Riefler the standard sidereal clock was obtained. Fauth & Co., of Washington, made, under the supervision of the U. S. Coast and Geodetic Survey, a half-seconds pendulum apparatus—Medenhall type—for the Observatory. Troughton & Simms, of London, received the order for the meridian circle, 6-inch aperture; and for a transit theodolite, 12-inch horizontal and vertical circles.

From the Zeiss Optical Works, Jena, a comparator was ordered. During 1901, the Chief Astronomer, contemplating installation in the Observatory, as well as in the Parliament and Departmental Buildings, of a system of electrically-controlled clocks, corresponded with many manufacturers, institutions and observatories: Paul Bunge; Howard Watch & Clock Co.; The Self-Winding Clock Co.; U. S. Coast and Geodetic Survey; U. S. Naval Observatory; Royal Observatory, Greenwich; Case School of Applied Science, Cleveland; Kullberg, London; E. Dent & Co., London; Favarger & Co., Neuchatel; Brèguet, Paris; and G. Borel, Paris.

On November 15, 1901, the printed specifications for contract for the erection of the Astronomical Observatory were received by the Chief Astronomer from the Department of Public Works.

On February 19, 1902, the Chief Astronomer gave to the writer a memorandum to proceed to Washington concerning the half-seconds pendulums ordered; the iced-bar base measuring apparatus, and precision level.

On February 28, 1902, the writer furnished a long report on his visit to Washington. Iced-bar apparatus was ordered.

On September 4, 1902, the writer observed for azimuth and defined the east and west line for contractor.

On October 12, 1902, the Chief Astronomer informed the writer that the Minister (Mr. Sifton) authorized the trans-Pacific

longitude work, utilizing the newly-laid "All Red Line" cable, thereby wiring the British Empire together astronomically and completing the first astronomic girdle of the world. The writer had charge of this work.

In January, 1903, the Chief Astronomer directed the writer to proceed to Cleveland to inspect and examine the completed equatorial, and if satisfactory, have shipped. Cost, with accessories, $14,625.

On June 30, 1904, the Chief Astronomer submitted memorandum of furniture and fittings required for Observatory, at a cost of $6,500. Building was now completed.

On July 4, 1904, the Chief Astronomer submitted a memorandum to the Minister (Mr. Sifton) which is herewith given in full:

As large expense is being incurred for the erection and outfitting of the Dominion Observatory, and as the sole justification for public expenditure is resulting public benefit, the following remarks upon the object of the observatory, with special reference to its utility, are submitted.

1. Primarily, the equipment of the Dominion Observatory is designed for the carrying out of definite lines of observation and investigation of a scientific character. These observations will not be astronomical only, but meteorological, seismological, spectroscopic, etc.

Such observations are for the general advancement of science, and, if conducted on a systematic plan, are of the highest value, though this value computed in dollars and cents may be remote. The absence of direct return from astronomical investigations calls for the aid of Government in a greater degree than do most other branches of science. State aid is given to astronomy by all civilized nations, and it is fitting that Canada should take part in the deevlopment of this branch of science.

2. The advantage to a nation in supporting such a science as astronomy is not confined to the ultimate results. In the very course of the work the men who do it derive special training, not only in the observing itself, but in the practical application of many branches of science which are closely bound up with modern astronomy.

This tends to develop a class of men of special training and knowledge, who will be useful to the country, wherever accurate observation and investigation is required. For instance, explorations, geodetic work, etc., call for men of this stamp whose trained intelligence enables them to adapt their methods to overcoming the peculiar difficulties which they encounter.

3. A branch of the work of the Observatory is the determination of

longitudes. The determinations which have already been made under this office have proved useful in the construction of maps, the correction of surveys, etc. They have from time to time been asked for by various departments of the public service. Under the organization which the completion of the observatory will render possible, they can, it is believed, be made more rapidly and economically.

4. Another branch of the work will be the transmission of accurate time to the city and the public buildings.

5. Arrangements will be made for testing chronometers, a service frequently required by many departments, but for which there are now few facilities. Minor instruments can also be tested, such as sextants, aneroid barometers, etc.

6. An indirect advantage will be the public interest which it is hoped to arouse in astronomy and science generally by the exhibition of the instruments to visitors at stated times. In many countries, above all the United States, large contributions to scientific objects have been made by private persons. There seems to be no reason why similar benefactions should not be made in Canada, if public interest were directed towards these objects.

Respectfully submitted,
(Signed) W. F. KING,
Chief Astronomer.

Minister of the Interior,
City.

In October, 1904, the equatorial was mounted.

In April, 1905, the Chief Astronomer and staff moved from their old quarters in the Thistle Block in the city to the Observatory. On April 29, 1905, the press visited the Observatory in the evening, was entertained, and the next day the Dominion Astronomical Observatory became known throughout Canada. and Dr. W. F. King became its Director, holding in addition as heretofore the title of "Chief Astronomer of the Department of the Interior."

In conclusion, a few statistics may be given of the money invested in the Dominion Astronomical Observatory. On August 28th, 1902, the contract for the main building was awarded to Theophile Viau for $74,999, and completed on June 25th, 1904. The heating contract was for $2,749, and was carried out by Butterworth. The transit house was built by McGillivray and Labelle for $14,789, and finished November 30th, 1905. Besides

the above, there were built two azimuth mark buildings, a small observatory for stellar photometric work, a magnetic hut, the Director's house and a machine shop, besides laying out and improvements to the grounds, so that the whole may be summarized:

HON. CLIFFORD SIFTON,

Observatory and auxiliary buildings	$180,000
Instrumental equipment	100,000
Library, 9,000 volumes	30,000
Total investment, Dominion Observatory	$310,000

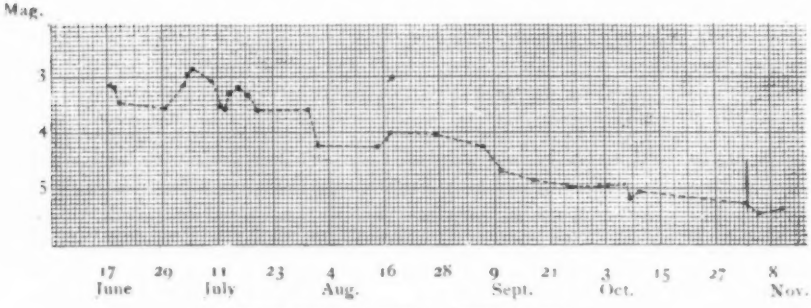
The above is a brief story of the genesis of the Dominion Astronomical Observatory. The data are mostly taken from official reports and files, and supplemented by extracts from the diaries of the writer, which are continuous in foolscap volumes from August 16, 1866, to date, over fifty years.

OTTAWA,
DOMINION ASTRONOMICAL OBSERVATORY,
July 6, 1918.

NOVA AQUILAE, NO. 3

By R. M. Motherwell

THE following magnitudes of Nova Aquilae are photographic and were determined by the extra-focal method, using a 6-inch doublet of 30-inch focus. Seed 30, G.E. plates were used throughout, the plate being set 5.5 mm. outside the focus. The star BD. + 1°, 3766 was used as the comparison star in all the measures. It is listed in "Harvard Annals" as of magnitude 5.04 and spectral type B5, a correction of —.12 of a magnitude being applied to reduce it to the photographic magnitude (see Harvard Annals, **80**,151). When the Nova became sufficiently faint, longer exposures were given, and a second comparison star, BD. — 1°, 3559, was used also. The agreement between the magnitudes derived from the two comparison stars was good, but the results given are those derived from measures using BD. + 1°, 3766, as the other star could not be used until the latter part of August. A comparison of these magnitudes with the visual estimates shows a difference of nearly one magnitude about June 20, the visual



LIGHT CURVE, NOVA AQUILÆ NO. 3

Photographic Magnitudes.

magnitude being brighter; while in the latter part of July the photographic magnitude is brighter by about half a magnitude. Judging by negatives obtained at this observatory in June with stained plates, this difference is due to the marked intensity of the H_α line.

TABLE

Date				Mag.	Date				Mag.
June	17	17	21	3·14	Aug.	16	17	07	4·13
	18	18	22	3·19		17	16	33	4·00
	19	16	44	3·45		27	14	05	4·04
	29	15	48	3·56	Sept.	6	15	51	4·25
July	3	16	29	3·15		10	14	34	4·69
	4	16	01	2·96		17	16	06	4·86
	5	17	01	2·93		24	14	43	4·95
	9	16	02	3·08		25	12	56	4·98
	11	17	04	3·53	Oct.	1	13	47	4·98
	12	15	23	3·56		3	14	46	4·96
	13	17	54	3·28		7	13	45	4·97
	15	15	51	3·20		8	13	08	5·18
	17	15	28	3·33		10	12	48	5·06
	19	14	29	3·60	Nov.	2	11	57	5·27
	30	16	06	3·60		5	12	27	5·44
Aug.	1	16	19	4·24		10	11	28	5·37
	14	15	26	4·25					

DOMINION ASTRONOMICAL OBSERVATORY,
OTTAWA, CANADA.

MEETINGS OF THE SOCIETY

At Toronto

November 26, 1918,—The Society held its regular meeting in the rooms, 198 College Street, at 8 p.m., the President, Mr. A. F. Miller, in the chair.

Mr. Reginald Langton Morris, Halifax, N.S., and Mr. F. J. Robertson, Seebe, Alberta, were elected members of the Society.

Under "observations", Mr. W. E. W. Jackson mentioned that there are a great many sunspots at present. Mr. A. F. Miller added that, notwithstanding the sunspots, there are comparatively few auroras visible in this locality. He also mentioned that Nova Aquilae is now far to the west, and is difficult to see. As it has become nebulous, it is much fainter than it was, and it will soon be invisible until next May, if visible then at all. Its color is a greenish white, and it is still possible to see the spectrum. It is now probably between the seventh and the eighth magnitudes.

J. B. Fraser, M.D., Toronto, read the paper of the evening on "Astronomy of the Seventeenth Century", which he prefaced by describing the conditions of ordinary life at that time. For floors in the houses they used rushes; for beds, pallets of straw; for stoves, they used fireplaces. The whole of Europe was steeped in superstition. Witches were burned, and as a cure for chin cough (which is now called whooping cough), a child that had it was passed under a donkey's belly at full moon. Astrology and astronomy were combined together. The different diseases to which human flesh is heir, came under the different constellations of the sky. Traces of this belief still remain in our language, as,

for example, the term "cancer", which was believed to have its origin under that constellation.

Astronomy was utilized for their own personal purposes of physical health to the utmost degree; prognosis of recovery was always given by the constellations. The two killing planets were Mars and Saturn, and they were especially dangerous when near together. A doctrine of this sort left its impression on language, as in the word "lunacy", and in some other words. Omens drawn from the stars and manipulated under psychic influences, aided or retarded recovery. Harvey's discovery of the circulation of the blood was strongly opposed by astrologers and medical practitioners of the time, but it has "won out", and medicine is now divorced from astronomy.

He next referred to the improvements in the telescopes of the seventeenth century, and to their quadrants and sextants; also to their views on the aurora borealis, and devoted the remainder of the paper to the lives and works of individual astronomers of that century, viz., Kirsch, a German; Cassini, an Italian; Newton, whose theory was bitterly opposed by the clergy of the day; Kepler, of Wurtemburg, who in 1599 went to Prague, where he aided Tycho and published his famous "laws"; Halley, who made the correct prediction of the famous comet named after him, and who wrote papers on the magnet and the magnetic needle; Flamstead, who made the first British catalogue of the stars; Hevelius, of Danzig; Gassendi, who wrote of the transit of Mercury, and in 1631 was the first to observe one; Huyghens, who was born at the Hague, in 1639, and who put forward the undulatory theory of light; Galileo, who was born in 1564, and discovered the four satellites of Jupiter in 1610, and who tested the laws of motion from the Tower of Pisa; Robert Hooke, who was born in the Isle of Wight, and who discovered sunspots and their changes.

The main features of seventeenth century astronomy were the disuse of astrology and the rise of astronomy in its place, attended by much opposition from the clergy.

A. F. HUNTER,
Recorder.

AT MONTREAL

December 12, 1918.—The Montreal Centre of the Royal Astronomical Society of Canada met on the evening of December 12th in the Engineering Building of McGill University, Mgr. C. P. Choquette, the President, in the chair. There was a fair attendance of members and visitors.

The President gave a lecture on "The Measurement of the Distances of the Heavenly Bodies." He began by discussing the various units of length employed in measuring distances, and explained the nature of parallax by diagrams and illustrations. He took up the question of the measurement of the earth's radius, and having ascertained this, the moon's parallax and distance were calculated.

The phenomenon of the transit of Venus and how it solves the question of solar parallax was very clearly explained and an actual computation made.

A hearty vote of thanks was presented to the lecturer by Mr. James Weir, B.Sc.

Mr. George Sample proposed the formation of a question bureau to assist members in the solution of various problems that present themselves from time to time. This was supported by Capt. Dr. Fournier and by Miss Mable Ellicott and agreed to by the members present.

The following were admitted into the Society, thirteen in all:

Joseph Edgar Guimont.
Francis E. M. Robinson, B.A.
Rev. A. J. Oakley.
E. Charles Carpenter.
H. E. Markham.
H. A. Ewart.
Rev. Principal Brandt, D.D.
Wm. Thos. Walmsley.
Miss Mable Ellicott.
Prof. Conrad Maureau.
Rev. James Ereaux.
R. T. Gaunt.
Hon. N. Perodeau, K.C.

W. T. B. CROMBIE,
Secretary.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

November, 1918

Precipitation.—The precipitation was quite deficient over the larger portion of the Dominion, but there were certain localities where conditions were reversed and more than the normal amount was registered. For instance, Northern British Columbia experienced considerably more snow and rain than the usual quantity. Winnipeg had a positive departure of about two-thirds. Also over Lakes Superior and Huron the average precipitation was exceeded, as it was at Montreal and over the Bay of Fundy. The chief negative departures occurred near Lakes Erie and Ontario, and over the greater part of the Province of Quebec, and were about half of the average quantity. The amount of snow that fell was everywhere light, except in the northern portion of the interior of British Columbia, where at the close of the month snow lay on the ground to a depth of 27 inches. In northern parts of Ontario and Quebec there was at the same time from 3 to 4 inches on the ground.

Temperature.—The temperature was from average to 2° below in the western half of British Columbia, and from the Bay of Fundy eastward to Cape Breton, otherwise it was above the average throughout the Dominion. The positive departure in the Western Provinces was especially marked, varying from 4° to 10°. In Ontario also it was very noticeable, ranging from 4° to 7°.

Temperature for November, 1918

Station	November		Station	November	
	Highest	Lowest		Highest	Lowest
Yukon			Kenora	52	- 3
Dawson	22	-22	Kimmount	58	8
British Columbia			Kingston	56	14
Atlin	40	1	Kitchener	63	16
Agassiz	57	25	London	64	19
Barkerville	38	7	Lucknow	58	16
Kamloops	56	14	Markdale	60	12
New Westminster	55	29	North Gower	56	10
Prince Rupert	61	28	Oshawa	70	20
Vancouver	54	30	Ottawa	52	12
Victoria	53	34	Paris	68	20
Western Provinces			Parry Sound	58	10
Battleford	58	0	Peterboro'	61	14
Calgary	69	8	Port Arthur	58	5
Edmonton	54	- 3	Port Burwell		
Medicine Hat	61	4	Port Dover	62	19
Minnedosa	48	4	Port Stanley	55	19
Moose Jaw	60	1	Queensborough	50	8
Oakbank	52	2	Ronville	55	0
Portage la Prairie			Southampton	59	16
Prince Albert	56	2	Sundridge		
Qu'Appelle	58	2	Stonecliffe	54	6
Regina	58	- 4	Stony Creek	68	18
Saskatoon	55	- 2	Toronto	66	18
Souris	53	2	Uxbridge	58	6
Swift Current	58	- 2	Wallaceburg	60	16
Winnipeg	52	6	Welland	67	18
Ontario			White River	52	- 6
Agincourt	62	20	*Quebec*		
Aurora	57	15	Brome	62	8
Bancroft	57	1	Father Point	49	11
Barrie	63	12	Montreal	48	12
Beatrice	67	10	Quebec	52	10
Bloomfield	59	13	Sherbrooke	51	8
Brantford	66	15			
Chapleau			*Maritime Provinces*		
Chatham	64	23	Charlottetown	48	14
Clinton	59	20	Chatham	48	10
Collingwood	63	14	Dalhousie		
Cottam	61	12	Fredericton	58	12
Georgetown	63	14	Halifax	54	14
Goderich			Moncton	50	11
Gravenhurst	59	13	St. John	55	14
Grimsby	66	18	Sussex	65	15
Guelph	63	15	Sydney	54	18
Haliburton	58	8	Yarmouth	57	19
Huntsville	58	7			

MAGNETIC OBSERVATIONS

October, 1918

During the month of October there was considerable disturbance of the earth's magnetic field. In the accompanying table is given a summary of the larger disturbances which occurred during the month.

Greenwich Mean Time								Range			
Beginning				Ending				Agincourt			Meanook
		h	m			h	m	H	Z	D	D
								γ	γ	′	′
Sept.	30	23		Oct.	1	16		149	255	63·2	111·2
Oct.	8	2	23		9	15		350	353	64·7	108·6
	15	4			18	24		559	435	93·5	169 7
	20	7	20		20	13		43	90	17·0	97·6
	30	23		Nov.	1	4		265	234	62·9	121·2

The most pronounced of these disturbances was the one from October 15th to 18th in which from October 16 4^h G.M.T. to 17^h G.M.T. the changes in Force and direction were exceedingly rapid and of large magnitude.

The aurora was observed throughout Canada particularly bright on the night of the 8th, and a little less so on the 3rd, and 15th. Only on five nights during the month are there no reports of the aurora.

Mr. Blake reports the sun spot activity during October to have continued quite pronounced.

AGINCOURT MAGNETIC OBSERVATIONS

Lat. 43° 47′ N.; Long. 79° 16′ W.

	October, 1918	D. West	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	6 39·0	15892	58342	74 45·8
	Maximum	7 28·5	15987	58445	
	Date of Maximum	16	15	8	
	Minimum	5 53·0	15428	57938	
	Date of Minimum	16	16	16	
	Monthly Range	1 35·5	559	507	
Mean Daily Amplitude	From hourly readings	10·1	49	38	
	From means of extremes	27·2	125	88	

MEANOOK MAGNETIC OBSERNATIONS

Lat. 54° 37′ N.; Long. 113° 21′ W.

	October, 1918	D. East	H	Z	I
		° ′	γ	γ	° ′
	Mean of Month	27 44·3	12928	60338	77 54·4
	Maximum	29 24·0			
	Date of Maximum	16			
	Minimum	26 31·5			
	Date of Minimum	31			
	Monthly Range	2 52·5			
Mean Daily Amplitude	From hourly readings	9·3			
	From means of extremes	52·0			

H and Z are given in Gammas. (1 γ = 0·00001 C.G.S.).

All results are reduced to I.M.S.

The value of I at Meanook is the mean of all the observations made during the month without regard to the time of day.

The value of H at Meanook is the mean of two observations made about the middle of the month, and the Z is obtained by the formula Z = H tan I.

W. E. W. J.

Earthquake Records by the Milne Seismograph

TORONTO

Sir Frederic Stupart, Director.

P.T. = Preliminary Tremors. S. = Secondary Waves. L.W. = Large Waves. A.C. = Air Currents. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1918	P. T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m	h m	h m	h m	h m	mm	
1921	Nov. 2			10 45·4) 10 54·4)			0·05	
1922	" 3			12 25·2) 12 28·6)	12 30·8	13 44·2?	0·7	Time doubtful.
1923	" 5			22 58·5) 23 00·8)	23 02·5	23 23·1	0·2	
1924	" 8	4 50·8	5 00·6	5 11·0) 5 14·4)	5 29·0	9 18·7	14·0	8,560 km. Clear record. Epicentre Lat. 51° 26′ N. Long. 145 E.
1925	" 11			7 57·4) 8 02·8)		8 17·6	0·1	
1926	" 12	21 50·9	21 55·6	21 57·8) 22 00·0)	22 05·2	23 17·5	3·3	2,990 km.
1927	" 16			6 14·8				Small micros. going on.
1928	" 18	19 00·0?	19 04·8	19 15·1	20 06·8	Micros.	3·0	3,070 km.? May be a dual earthquake. S. waves large.
1929	" 22			16 33·5?) 16 37·6)	16 43·5	16 56·6	0·3	
1930	" 23	23 25·7?	23 36·3?	0 17·9	0 22·5	1 38·7	0·3	
1931	" 25			2 27·3) 2 35·3)	2 36·3	3 12·2	0·3	
1932	" 30			7 23·8	7 28·4	8 18·4	0·4	Disturbance abruptly became smaller at 7h 31·4m.

26th Heavy micros. began after 22 hours continuing to 15 hours of 27th.

Boom period·18 seconds. Pillar inclination 1mm. = 0″·45.

VICTORIA, B. C.

F. N. DENISON, SUPERINTENDENT.

No.	Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
		h m s	h m s	h m s	h m s	h m s	mm	
1924	Nov. 3	11 43 34	11 54 00	12 06 31) 12 19 02)	12 24 03	12 32 04	0·5	9,310 km.
1925	" 8	4 47 25	4 53 22	5 03 47	5 20 29	8 48 01	6·0	4,180 km. Kamchatka.
1926	" 12	21 54 14?	22 02 08	22 12 52	22 20 28	23 05 06	1·0	6,330 km. May be West Indies.
1927	" 16	6 14 04?		6 18 59	6 20 27	6 27 50	0·2	
1928	" 18	18 55 14	18 59 40	19 08 02	19 44 25	22 01 09	9·0	2,770 km. S. waves well defined
1929	" 20				6 57 19		0·1	
1930	" 22	16 05 00?			16 29 30	17 01 30	0·2	
1931	" 23	23 21 36	23 30 27	23 41 45?) 23 46 11?)	0 06 51	1 33 24	0·5	7,400 km.
1932	" 30		7 09 03	7 16 44	7 22 07	7 41 02	0·4	Disturbance became abruptly less at 7h 24m 04s.

Boom period 18 seconds. Pillar inclination 1mm. = 0″·54

VERTICAL SEISMOGRAPH

Date 1918	P.T. Comm.	S. Comm.	L.W. Comm.	Max.	End	Max. Amp.	Remarks
	h m s	h m s	h m s	h m s	h m s	μ	
Nov. 8	4 47 00	4 53 45	5 04 40	5 22 08	?	14	5,050 km. Kamchatka.
" 18		19 00 18	19 07 38	19 44 34	?	4	

ASTRONOMICAL NOTES

On the Essence of Physical Relativity.—In an important investigation recently reported, Mr. Leigh Page has determined an expression for the translatory force required to sustain an assigned varying velocity in an electrostatic system of a certain type, that namely which it has been usual to investigate as a model of an electron in analytical discussions. The expression contains terms involving the acceleration of the system and its time-gradients, but no term involving its velocity except in combination with these other quantities. The application of his formula to which Mr. Page restricts himself is to challenge a result that an isolated radiating system is subject to retarding force from the reaction of its own radiation of amount equal to its velocity multiplied by rate of radiation divided by c^2. The necessity for such refutation is based on the idea that on principles of relativity the velocity of an isolated body could have no meaning. But the formula obtained seems to leave this question as it was: for equally the acceleration of the isolated body could have no meaning; and moreover, though the thrust of the radiation is, in this case compensated, the velocity appears to be actually involved in the formula in the same manner as the impugned result would require for this particular problem of a convected electrostatic system, for which the radiation is extremely transient and very slight in the absence of extraneous force.

It has always seemed to me that this subject, which may be

described as that of interaction of the æther with uniform motion, though of slight account phenomenally, is theoretically of high significance, in that it is destined perhaps to throw light on the nature of the forward momentum that is convected by radiation, and thence on the intimate dynamical nature of radiation itself and the physical function of the æther. I therefore propose briefly to indicate what I hold, provisionally of course, to be their present trend of knowledge.

The true essence of the relativity of external knowledge is that we can investigate a system only in relation to some other system, and the most convenient perhaps the only feasible other system has been hitherto the ideal Newtonian frame of reference of space and time; for that is the canonical system, so to speak, with regard to which dynamical principles take on an ideal simple form, and it is a system which is being determined with continually expanding precision by the progress of astronomical science.

The special question now in evidence is — Is it now expedient to exchange this frame of reference, corresponding to c infinite, for another far more complex but very slightly different continuum having a finite space-time modulus c? The more fundamental question is — Are we to assign to either frame dynamical properties, typified by propagation of physical effect in space in terms of undulations sustained by stress and inertia, or are we to assign to it properties solely geometrical and regard all physical effect as merely projected in duration across space? The forms of special unrestricted relativity which have been recently current ultimately demand and perhaps prefer the latter course; and such modes of expression can apparently be elaborated so as to include most of optics, though perhaps in an artificial and unfruitful manner, if we replace the Newtonian scalar corpuscles of light by projected vector elements of fields of potential (not however conserved in value) from which forces would be analytically derivable. Mr. Page's work has improved very remarkably such a scheme of projected influence by showing that, provided c-relativity is postulated for space and time, it is ele-

ments of longitudinal electric force that may be regarded as projected from the sources, and are moreover conserved after the manner of *quanta* as they travel onward.

There is no absolute criterion to decide between the two ideals. The first order of ideas has proved itself as the foundation on which the interlaced fabric of electric and optical science has been actually constructed: the other seems to offer as yet only somewhat ingenuous and disjointed though significant expression for certain striking features of recent discovery which the former has not yet succeeded in assimilating, and seems to require us to obliterate the course of evolution of the science or perhaps to retain it as a mere historical survival.

All these modes of restatement of departments of physical science in more expressly relative terms may be comprehended as partial analytic developments of the far wider principle of the purely relational character of our external knowledge, which was advanced and systematically fortified with great abstract force in the general metaphysical domain by Bishop Berkeley; a principle by means of which he passed on to examine the criterion of real objective existence, and one which was well understood in its present aspect by his friends in Yale College nearly two centuries ago.

Thus in these matters we are hardly concerned with refuting any theory, for all are relative; it is fruitless to traverse any proposition, unless we take into account the definitions and context in which it subsists. The question is, as to which scheme of formulation gives as a whole the closest and most expressive representation of the complex of natural knowledge, and affords the most promising clue to its future elaboration and extension. But a choice does not by any means preclude development along other promising but provisional lines for which an interpretation has yet to be found.—Sir Joseph Larmor, Cambridge, England, "Proceedings of the National Academy of Sciences," U.S.A., November, 1918.

J. R. C.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

Queries

APPARENT SIZE, STELLAR MAGNITUDE

1. How are the "apparent" sizes of the heavenly bodies measured? Example, Jupiter 40" diameter.

2. What is the "star magnitude" of Jupiter's sixth and seventh satellites? —F. Kerr, Alexandria.

Answers

1. The apparent distance between two points in the sky (such as two stars, or the opposite ends of the diameter of a planet) is the *angle* between the rays of light which come from those two points and meet in the eye. It is measured by means of a micrometer in the eyepiece of a telescope, a description of which will be found in any work on astronomy.

However the method can be illustrated in a simple way. Suppose we wish to determine the apparent diameter of the full moon. Stick a 5-cent silver coin on a wire and then move back from it until the coin just covers the moon's disc; then get some one to measure the distance of the coin from the eye. It will be about 70 inches; and the diameter of the coin is about $\frac{5}{8}$ inch. Now draw a circle on a sheet of paper and suppose its radius to be 70 inches, and imagine the eye at the centre of it. If now we take a portion of the circumference $\frac{5}{8}$-inch in length and draw straight lines from its two ends to the centre, the angle between these radii will be the "angular diameter" of the moon, and we can calculate it in this way. The diameter of the circle is 140

inches, and hence the circumference is 440 inches; also, the entire angle at the centre, opposite the circumference, is 360° or 21,600′. If then 440 inches subtends (or is opposite) an angle of 21,600′, 5/8 inch will subtend an angle of 31′ (nearly).

2. The stellar magnitudes of Jupiter's sixth and seventh satellites are given as 14 and 16, respectively. (See "Handbook" for 1917, p. 52).

THE OBSERVATORY CLUB, OTTAWA

The staff of the Dominion Observatory, at Ottawa, numbering at present 13, several being overseas, inaugurated last year a Club, for the discussion of subjects of special interest to its members. It has resulted in lasting good to its members— and of interest to visitors, as the present writer can testify. Dr. Klotz has sent me the program for the present season. It is as follows :—

Name	Date	Subject
Otto Klotz	October 18	Visits to European Observatories.
R. E. DeLury	November 8	The Radiation of the Sun.
D. B. Nugent	November 15	Fundamental Star Places.
W. E. Harper	November 28	New Stars. Nova Aquilæ 3 and Others
E. A. Hodgson	December 13	The Deformation Instrument.
J. B. Cannon	January 17	Binary Orbits.
R. M. Motherwell	January 31	Science of Photography.
W. A. Dier	February 14	Wireless Detectors.
R. J. McDiarmid	February 28	Parallax Determinations.
W. C. Jaques	March 14	Variation of Latitude
C. A. French	March 28	Reduction of Magnetic Observations to a Common Epoch.
A. H. Swinburn	April 4	The Transit Micrometer Screw.
R. M. Stewart	April 11	Relativity.

TWO NEW COMETS IN 1918

The number of new comets discovered in 1918 was exceptionally small, undoubtedly because the world was busy with war.

The first was discovered by William Reid, in South Africa, on June 12, 1918, in R.A. 9h 16m 36s, Decl. – 8° 10′, near α Hydræ, with daily motion 48′ due south. It could not be observed from the northern hemisphere and no further observations have been published.

The second was discovered by R. Schorr, at Hamburg, Germany, on November 23, in R.A. 4h 12m 9s, Decl. + 11° 35′, not very far from Aldebaran in Taurus. It was of 14th magnitude, had already passed perihelion and was growing fainter.

Wolf's periodic comet was observed by Jonckheere, at Greenwich, on July 9, 1918, on its fifth return since it was discovered in 1884.

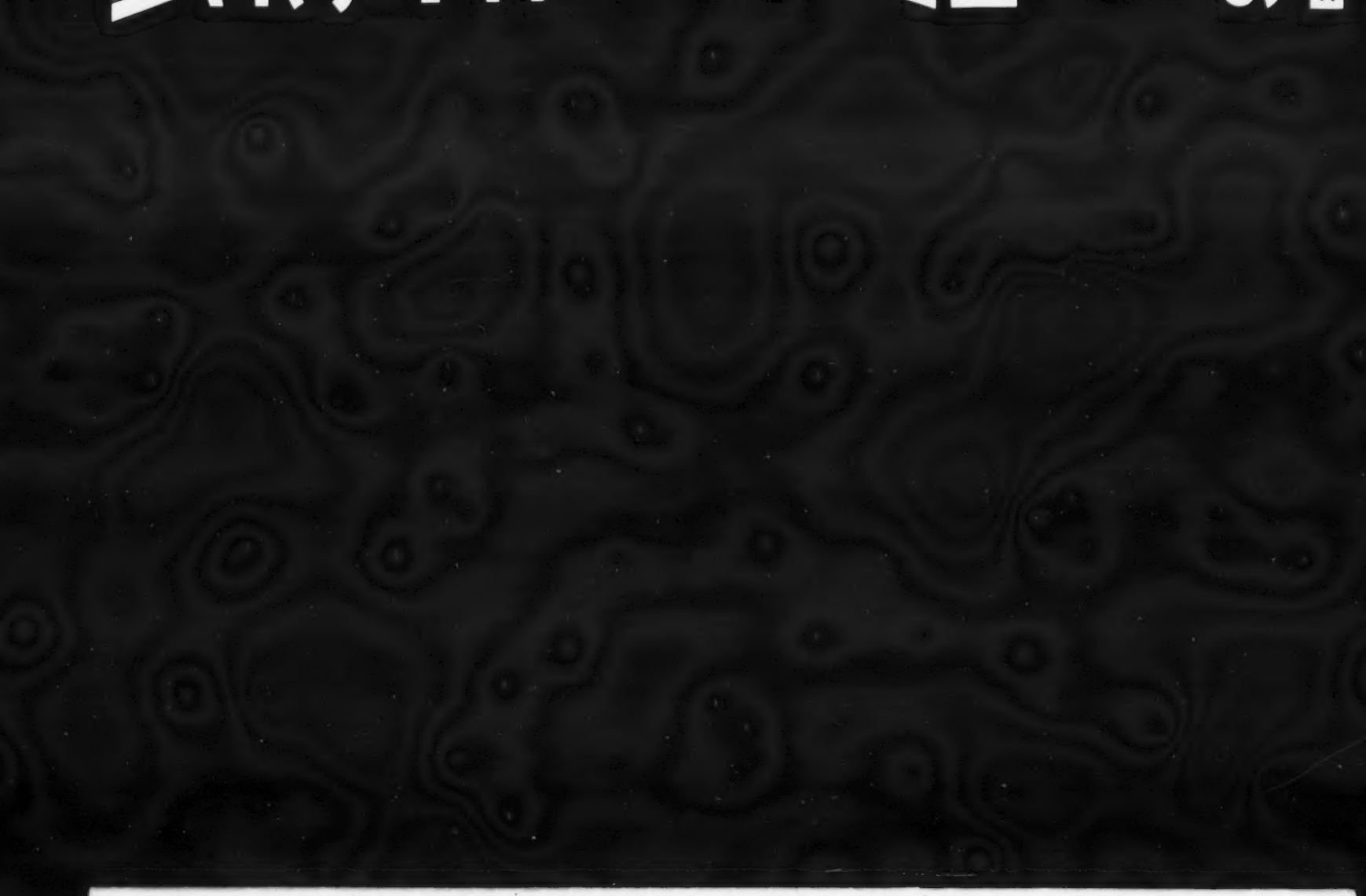
Borrelly's periodic comet was observed by Fayet, at Nice, France, on August 7, 1918. This was its third re appearance.

PROPER MOTION BY THE STEREOSCOPIC METHOD

On page 326 of this Journal for 1918 was printed a quotation from the English Mechanic in which it was claimed that Sola, of Barcelona, Spain, had invented a new instrument by which the proper motion of Barnard's 'runaway' star had been determined from two negatives taken only twenty hours apart.

In a note to the present writer Professor Frank Schlesinger, of the Allegheny Observatory, states that the above report cannot be correct, since the motion "in twenty hours is 0″·025 and no plate (on the scale that he is employing) will reproduce so small a change, to say nothing of measuring it."

C. A. C.



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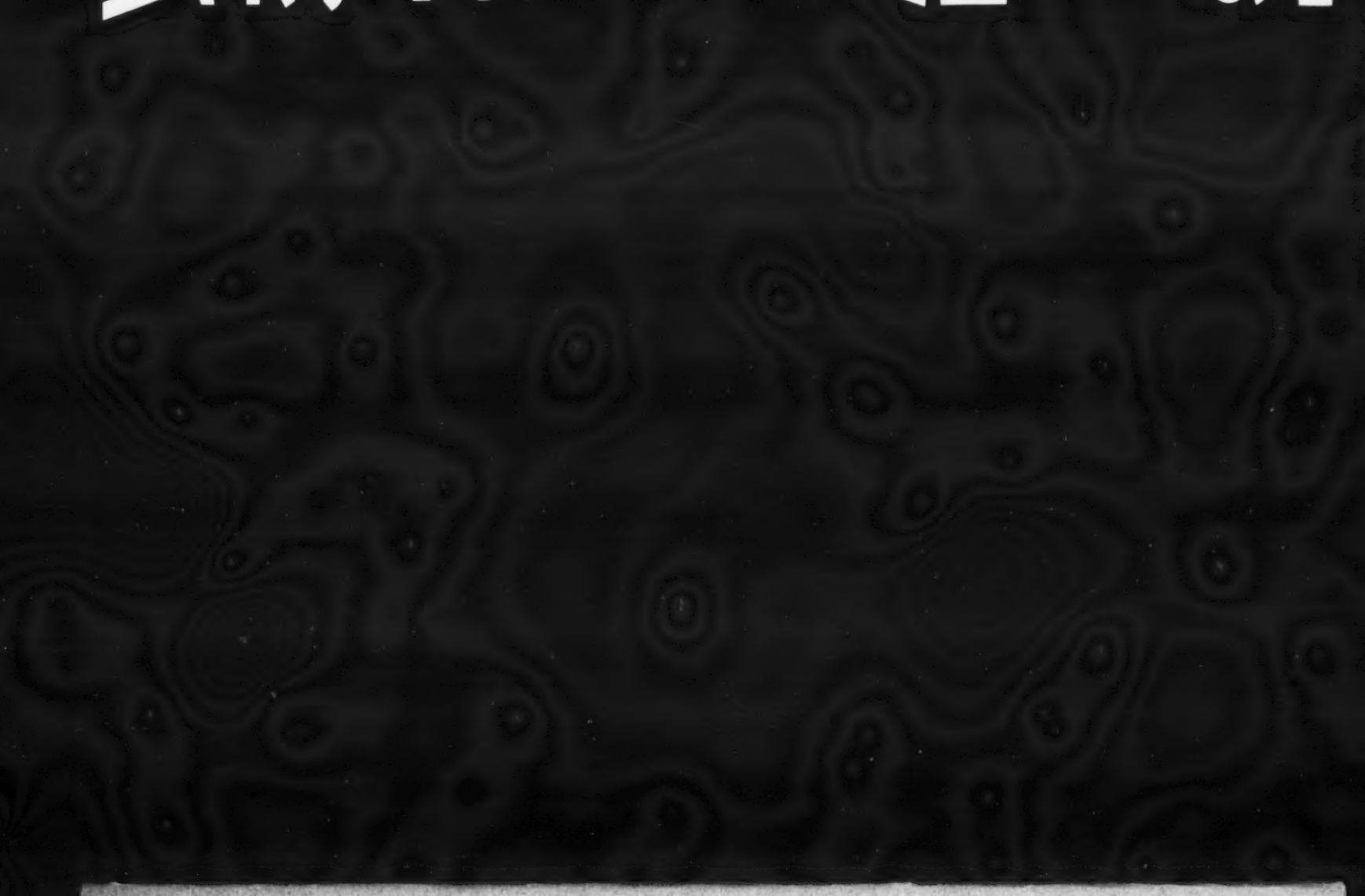
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